WHAT IS CLAIMED IS:

1. A method of controlling a fuel injection amount of an internal combustion engine with respect to a suction stroke for which fuel is injected, comprising the steps of:

estimating an operating state quantity of the engine to be established at the time of closing of an intake valve in the suction stroke in question, at a point in time prior to the time of closing of the intake valve;

estimating an intake air amount in the suction stroke based on the estimated operating state quantity;

calculating, as a pre-correction estimated necessary fuel amount, a provisional fuel amount that is needed along with the estimated intake air amount to achieve a target air/fuel ratio;

calculating an actual necessary fuel amount as an amount of fuel actually needed for achieving the target air/fuel ratio in a previous suction stroke that precedes the suction stroke in question, based on a known value of the operating state quantity, at a point in time after closing of the intake valve in the previous suction stroke;

calculating an actual intake fuel amount as an amount of fuel actually inducted into a cylinder of the engine during the previous suction stroke, based on at least an amount of fuel actually injected for the previous suction stroke;

determining an excess or shortage of the fuel in the previous suction stroke based on the calculated actual necessary fuel amount and the calculated actual intake fuel amount, and calculating a fuel feedback correction amount corresponding to the determined excess or shortage of the fuel;

calculating a normal estimated necessary fuel amount by correcting the pre-correction estimated necessary fuel amount with the calculated fuel feedback correction amount;

calculating a fuel injection amount based on at least the calculated normal estimated necessary fuel amount; and

injecting the fuel having the calculated fuel injection amount for the suction stroke in question, at a point in time before the time of closing of the intake valve in the suction stroke.

2. An apparatus for controlling a fuel injection amount of an internal combustion engine including a fuel injector that injects a fuel in response to a command, with respect to a suction stroke for which the fuel is injected, comprising:

an operating state quantity estimating unit that estimates an operating state quantity of the engine to be established at a point in time that is later than the present time;

an operating state quantity acquiring unit that acquires an actual operating state quantity of the engine established at a point in time that is earlier than the present time;

an estimated intake air amount calculating unit that calculates an estimated intake air amount as an amount of intake air that will be present in a cylinder of the engine at the time of closing of an intake valve in the suction stroke in question, at a first predetermined point in time that is earlier than the time of closing of the intake valve in the suction stroke, the estimating intake air amount being calculated based on the operating state quantity to be established at a point in time later than the first predetermined point, which quantity is estimated by the operating state quantity estimating unit, and an air model that models the behavior of air in an intake system of the engine;

a pre-correction estimated necessary fuel amount calculating unit that calculates a pre-correction estimated necessary fuel amount as a provisional amount of fuel needed in the suction stroke in question, based on the estimated intake air amount, at a second predetermined point in time that is later than the first predetermined point and is earlier than the time of closing of the intake valve in the suction stroke;

an actual intake air amount calculating unit that calculates an actual intake air amount as an amount of intake air that was actually present in the

cylinder at the time of closing of the intake valve in a previous suction stroke that precedes the suction stroke in question, at a third predetermined point in time that is later than the time of closing of the intake valve in the previous suction stroke and is earlier than the time of closing of the intake valve in the suction stroke in question, the actual intake air amount being calculated based on the actual operating state quantity acquired by the operating state quantity acquiring unit and the air model;

an actual necessary fuel amount calculating unit that calculates an actual necessary fuel amount as an amount of fuel actually needed in the previous suction stroke, based on the calculated actual intake air amount, at a fourth predetermined point in time that is later than the third predetermined point and is earlier than the time of closing of the intake valve in the suction stroke in question;

an actual intake fuel amount calculating unit that calculates an actual intake fuel amount as an amount of fuel actually inducted into the cylinder during the previous suction stroke, at a fifth predetermined point in time that is earlier than the time of closing of the intake valve in the suction stroke in question, the actual intake fuel amount being calculated based on at least an amount of fuel actually injected for the previous suction stroke;

a fuel feedback correction amount calculating unit that calculates a fuel feedback correction amount based on the calculated actual necessary fuel amount and the calculated actual intake fuel amount, at a sixth predetermined point in time that is later than the fourth and fifth predetermined points and is earlier than the time of closing of the intake valve in the suction stroke in question;

a normal estimated necessary fuel amount calculating unit that calculates a normal estimated necessary fuel amount as a normal fuel amount needed for the suction stroke in question, by correcting the calculated pre-correction estimated necessary fuel amount with the fuel feedback correction amount, at a seventh predetermined point in time that is later than the second and sixth predetermined points and is earlier than the time of closing of the intake valve in the suction stroke in question;

a fuel injection amount calculating unit that calculates a fuel injection amount as an amount of fuel to be injected from the fuel injector for the suction stroke in question, based on at least the calculated normal estimated necessary fuel amount, at an eighth predetermined point in time that is later than the seventh predetermined point and is earlier than the time of closing of the intake valve in the suction stroke in question; and

a fuel injection commanding unit that generates a command to inject the fuel having the calculated fuel injection amount, to the fuel injector, at a ninth predetermined point in time that is later than the eighth predetermined point and is earlier than the time of closing of the intake valve in the suction stroke in question.

3. The apparatus according to claim 2, wherein:

the fuel feedback correction amount calculating unit calculates the fuel feedback correction amount based on at least a time integral value of a difference between the calculated actual necessary fuel amount and the calculated actual intake fuel amount; and

the estimated intake air amount calculating unit and the actual intake air amount calculating unit are constructed such that, when the internal combustion engine is in a steady operating state, the estimated intake air amount calculated by the estimated intake air amount calculating unit and the actual intake air amount calculated by the actual intake air amount calculating unit become substantially equal to each other.

4. The apparatus according to claim 2, further comprising:

an actual fuel deposition amount calculating unit that calculates an actual fuel deposition amount as an amount of fuel deposited after a particular suction stroke and before a suction stroke that comes next to the particular suction stroke, based on a fuel injection amount that is actually injected for the particular suction stroke, an actual fuel deposition amount as an amount of fuel deposited after a

suction stroke that precedes the particular suction stroke and before the particular suction stroke, and a fuel behavior model that represents the behavior of fuel deposited in an intake system of the engine, wherein:

the actual intake fuel amount calculating unit calculates the actual intake fuel amount as an amount of fuel actually inducted into the cylinder during the previous suction stroke, based on a forward model of the fuel behavior model, the actual intake fuel amount being calculated from an amount of fuel actually inducted into the cylinder during the previous suction stroke, out of an amount of fuel actually injected for the previous suction stroke, and an amount of fuel actually inducted into the cylinder during the previous suction stroke, out of the actual fuel deposition amount calculated by the actual fuel deposition amount calculating unit as an amount of fuel actually deposited after a second previous suction stroke that precedes the previous suction stroke and before the previous suction stroke; and

the fuel injection amount calculating unit calculates the fuel injection amount based on a reverse model of the fuel behavior model so that a sum of an amount of fuel to be inducted into the cylinder during the suction stroke in question, out of the fuel injection amount to be injected for the suction stroke, and an amount of fuel to be inducted into the cylinder during the suction stroke in question, out of the fuel deposition amount calculated by the actual fuel deposition amount calculating unit as an amount of fuel actually deposited after the previous suction stroke and before the suction stroke in question becomes equal to the calculated normal estimated necessary fuel amount.

5. The apparatus according to claim 4, wherein:

the fuel feedback correction amount calculating unit calculates the fuel feedback correction amount based on at least a time integral value of a difference between the calculated actual necessary fuel amount and the calculated actual intake fuel amount; and

the estimated intake air amount calculating unit and the actual intake air amount calculating unit are constructed such that, when the internal combustion

engine is in a steady operating state, the estimated intake air amount calculated by the estimated intake air amount calculating unit and the actual intake air amount calculated by the actual intake air amount calculating unit become substantially equal to each other.

6. The apparatus according to claim 4, wherein:

the actual intake fuel amount calculating unit determines a fuel deposition rate and a fuel remaining rate used by the forward model of the fuel behavior model, based on the actual intake air amount for the time of closing of the intake valve in the previous suction stroke, and calculates the actual intake fuel amount based on the forward model of the fuel behavior model using the determined fuel deposition rate and fuel remaining rate; and

the fuel injection amount calculating unit determines a fuel deposition rate and a fuel remaining rate used by the reverse model of the fuel behavior model, based on the estimated intake air amount, and calculates the fuel injection amount based on the reverse model of the fuel behavior model using the determined fuel deposition rate and fuel remaining rate.

7. The apparatus according to claim 6, wherein:

the fuel feedback correction amount calculating unit calculates the fuel feedback correction amount based on at least a time integral value of a difference between the calculated actual necessary fuel amount and the calculated actual intake fuel amount; and

the estimated intake air amount calculating unit and the actual intake air amount calculating unit are constructed such that, when the internal combustion engine is in a steady operating state, the estimated intake air amount calculated by the estimated intake air amount calculating unit and the actual intake air amount calculated by the actual intake air amount calculating unit become substantially equal to each other.